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GUIDELINES FOR PREPARATION PROGRAMS OF TEACHERS OF SECONDARY SCHOOL SCIENCE AND MATHEMATICS.

NATIONAL ASSN. OF STATE DIR. OF TEACH. EDUC. CERT.

AMERICAN ASSN. FOR THE ADVANCEMENT OF SCIENCE

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PRESENTED IN THIS VOLUME ARE GUIDELINES AND RECOMMENDATIONS FOR ACADEMIC SUBJECT MATTER PREPARATION OF SCIENCE AND MATHEMATICS TEACHERS. THE INTRODUCTORY SECTION OF THE VOLUME STATES--"THESE GUIDELINES ARE OFFERED AS A RESOURCE TO BE DRAWN UPON BY INSTITUTIONS OF HIGHER EDUCATION AND STATE EDUCATION AGENCIES IN DEVELOPING AND IMPROVING THEIR PROGRAMS FOR THE PREPARATION OF SCIENCE AND MATHEMATICS TEACHERS FOR THE SECONDARY SCHOOLS." EIGHT GUIDELINES COMMON TO THE PREPARATION OF TEACHERS IN THE SCIENCES AND MATHEMATICS ARE PRESENTED. RECOMMENDED PROGRAMS BASED ON THE EIGHT GUIDELINES ARE PRESENTED FOR (1) BIOLOGY, (2) CHEMISTRY, (3) PHYSICS, (4) PHYSICAL SCIENCES, (5) JUNIOR HIGH SCHOOL SCIENCE, (6) MATHEMATICS, AND (7) EARTH AND SPACE SCIENCE. AN NASDTEC DECLARATION OF POLICY IS INCLUDED. THIS DOCUMENT IS ALSO AVAILABLE FROM NASDTEC-AAS STUDIES, 1515 MASSACHUSETTS AVENUE, N.W., WASHINGTON, D.C. (RS)

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GUIDELINES

for

PREPARATION PROGRAMS

of

TEACHERS

of

SECONDARY SCHOOL

SCIENCE AND MATHEMATICS

Recommendations
of the Teacher Preparation-
Certification Study
of the
National Association of State
Directors of Teacher Education
and Certification
and the
American Association for the
Advancement of Science
with the support of the
Carnegie Corporation of New York

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Acknowledgments

We wish to express our deep appreciation to the many individuals, organizations, and agencies who have shared enthusiasm, responsibility, and hard work in the production of these Guidelines. The real acknowledgment of their efforts will come as states and teacher preparation institutions implement the Guidelines in improving preparation programs for teachers of secondary school science and mathematics.

Assistance in identifying persons to participate at these conferences was received from the American Association of Colleges for Teacher Education, the Council of Chief State School Officers, the National Commission on Teacher Education and Professional Standards, the National Council for Accreditation of Teacher Education, and the sponsoring organizations. American education is indebted to these groups, to the persons who took part in the conferences, and to the Carnegie Corporation of New York for their support in making this study possible.

NATIONAL ASSOCIATION OF STATE DIRECTORS OF TEACHER EDUCATION AND CERTIFICATION

Teacher Preparation - Certification Study

in cooperation with

the

American Association for the Advancement of Science

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Preface

This publication is concerned with the subject-matter preparation of secondary school teachers of science and mathematics. The Guidelines set forth in the pages that follow result from a unique study initiated in December 1959 by the National Association of State Directors of Teacher Education and Certification (NASDTEC) in cooperation with the American Association for the Advancement of Science (AAAS), under a grant from the Carnegie Corporation of New York.

Early in 1960 a series of four work conferences were held in Chicago, Salt Lake City, Atlanta, and New York. Participants at these conferences included representatives from the sciences, mathematics, and teacher education. These participants came from colleges and universities, industry, the Federal government, regional accrediting associations, state education departments, professional and learned societies, and local school systems.

The study culminated in a national conference held at Pennsylvania State University, University Park, Pennsylvania, June 18-20, 1961. About 150 persons took part. They were representatives of the same associations and agencies as were those in the work conferences in 1960.

During the course of the study, thousands of copies of several drafts of the Guidelines were studied by state teacher education councils, teacher preparation faculties, and state education department sponsored conferences. The American Association of Colleges for Teacher Education nominated several institutions to study the Guidelines intensively and suggest changes. This was done with the cooperation of the state teacher education and certification directors in the states where the colleges were located.

Materials of particular help to the participants in the conferences were the reports of the AAAS Cooperative Committee on the Teaching of Science and Mathematics, the Committee on Undergraduate Preparation of the Mathematical Association of America, the Commission on Mathematics Program for College Preparatory Mathematics of the College Entrance Examination Board, and curriculum studies from various states.

These Guidelines have grown out of these conferences, and reflect the suggestions and points of view of these participants. Therein lies the uniqueness of the study, which was a conscious effort to draw upon and distill from the perspectives of these divers resources in American education the wisdom that is needed to consider imaginatively the matters dealt with in the Guidelines. Specifically, the constructive way in which scientists and mathematicians from higher education institutions and educators concerned professionally with the schools have worked together is worthy of particular note.

Introduction

This study, sponsored by the National Association of State Directors of Teacher Education and Certification in cooperation with the American Association for the Advancement of Science, and supported by the Carnegie Corporation of New York, has been concerned with the characteristics, adequacy and quality of collegiate programs in the subject-matter areas of the sciences and mathematics. In the Guidelines that follow, therefore, attention is given only to programs of preparation in these teaching fields. This preoccupation with these areas of specialization implies no lack of awareness of the importance of the other two basic elements in the education of all teachers: general education and professional education.

The Standards set forth by the National Council for Accreditation of Teacher Education for the development of teacher education curricula include the following statements:

> All teacher education curricula should require a pattern of general education in such an amount and of such a nature as to assure that all teachers will be broadly educated and cultured persons.
>
> The nature and amount of subject-matter concentration required in each teacher education curriculum should be such as to assure adequate background for the position to be filled. There may be differences . . . among the various teaching fields at the secondary level.
>
> The nature and amount of professional education required for each curriculum should be such as to assure competence for the position to be filled.
>
> The total pattern . . . should provide general education, subject specialization, and professional education in such amount as to assure reasonable competence in each area and provide balance in the total program.[1]

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[1] National Council for Accreditation of Teacher Education, *Standards and Guides for Accreditation of Teacher Education* (mimeographed, 1960), p. 15. The policy of NASDTEC is equally clear on this subject: "NASDTEC believes that the growing and changing demands on society in the last half of the twentieth century require that . . . all teachers have a broad education in the arts, the sciences and the humanities; intensive study in the subject-matter fields to be taught; and thorough preparation in the education process . . ." (NASDTEC, *Declaration of Policy on Teacher Education and Certification*, mimeographed, June 24, 1958, p. 1.)

Although the four invitational conferences in 1960 that were convened in connection with this study did not explicitly give consideration to general and professional education, there was an implicit assumption that these are essential elements in the education of all teachers. While the body of this report relates to the subject-matter preparation of science and mathematics teachers for the secondary schools, the study supports the position that all teachers should be liberally educated and professionally competent.

Purpose and Use of the Guidelines

These Guidelines are offered as a resource to be drawn upon by institutions of higher education and state education agencies in developing and improving their programs for the preparation of science and mathematics teachers for the secondary schools. The principles set forth and the examples of their implementation should make for flexibility in programs from state to state and institution to institution, but still assure adequate subject-matter background on the part of teachers of science and mathematics.

A dominant purpose in the development of these Guidelines has been to furnish a flexible instrument for state directors of teacher education and certification in discharging their chief responsibility—to assure the provision of adequately prepared teachers for the public schools.

The legal responsibility for the approval of institutions and programs rests with each state department of education. NASDTEC regards NCATE as the national agency for the development and administration of standards for the accreditation of all teacher education institutions. State accreditation where available, as well as regional accreditation, is a prerequisite for NCATE accreditation. The NCATE standards place upon the institution the responsibility for planning programs in harmony with its avowed objectives. Many institutions now offering teacher education in the various states are not yet accredited by NCATE and doubtless some will have difficulty in meeting its standards when they are evaluated. Others may not choose to apply for NCATE accreditation. Regardless of the NCATE status of an institution, the state department of education has a leadership responsibility in the area of program planning and program approval. This document and the NCATE standards should prove useful to the state department of education in its role of advising with and approving programs of teacher preparation in the institutions within the state. These Guidelines are intended to supplement, and neither to repeat nor replace the standards of NCATE and regional accrediting associations.

The state directors of teacher education and certification will use these Guidelines in a variety of ways. Many state departments have adopted "the approved program approach" to teacher preparation and certification—a process which places upon each institution the responsibility for developing teacher preparation programs on the basis of guidelines adopted by the state.

Those set forth in this document are offered as a starting point for the state-adopted version, to be modified as much or as little as cooperative study indicates. It is urged that such cooperative study be patterned after the process by which the present Guidelines were developed—broadly involving all logically interested persons and groups.

An Example of the Use of the Guidelines

As an example, one state department of education has presented these preliminary Guidelines to its Advisory Committee on Teacher Education and its Council on Public Higher Education for study and consideration. These Guidelines were made available for study by faculties of institutions that prepare teachers. The director of teacher education, in cooperation with appropriate committees, has held state conferences on the implication of these Guidelines for programs for preparing teachers. This latest edition of the Guidelines will be used in a similar cooperative manner for statewide consideration as a means of developing a state-approved version for use when the director of teacher education and certification is in consultation with college representatives in regard to the scope and sequence of courses to be included in planning mathematics and science programs for teachers. Then, when the state team of evaluators visits a campus to accredit an institution offering teacher preparation programs, these Guidelines will be used in determining the adequacy of the programs in mathematics and science. Every institution accredited by NCATE, as well as those holding only state accreditation, must submit its planned curriculum to the state department of education for approval as a basis for certification of its students. The director of teacher education will use these Guidelines, as adopted by the state board of education, for developing criteria for use in passing judgment on the adequacy of the curricula submitted for approval. Ideas arrived at jointly and expressed in these Guidelines will thus be brought into the programs of the institutions within the state.

Other states may find an adaptation of these procedures helpful.

The Small Secondary School

The small secondary school has posed problems relating to teacher assignment, and consequently to teacher preparation, that may persist in some areas for many years. While school district consolidation continues to eliminate many of these schools each year, means must be found to improve educational offerings to those students who find themselves instructed by teachers with multiple assignments.

No attempt is made in this document to set up programs to fit the many types of small secondary schools throughout the country. It is recommended that the states make such adjustments in teacher preparation as are necessary with as little diminution in quality as possible.

It is also recommended that states and local school districts eliminate

the situation rapidly by taking the administrative steps required in order to achieve equality of educational opportunity for all youth.

Objectives of Subject Matter Specialization

Many of the objectives of science and mathematics teaching are shared by all science instruction at all grade levels and in all the various science subjects. Among these objectives are: (1) as high a level as possible of that scientific and mathematical literacy necessary for intelligent citizenship today; (2) development of a concept of science and mathematics as an accumulated body of knowledge and of a concept of scientific methods of inquiry; (3) development of modes of thought that encourage critical thinking and problem-solving ability; (4) understanding of the basic interrelationships within and among the various sciences and mathematics; (5) understanding of the broad conceptual schemes of science and mathematics including the concepts and principles of which the schemes are structured; (6) a more penetrating understanding of the relationships of current science and mathematics to the other activities of man and to his cultural patterns.

Science courses, taught with these objectives in mind, are not only essential for the preparation of well-qualified science teachers, but are also appropriate for inclusion in the program of general education.

Curricular Implications

The subject-matter portion of the curriculum for future teachers should be selected and organized on the basis of consideration for and study of the needs of teachers in the schools. The conception of teacher needs in science on which programs are based should, in turn, be based on a conception of a desirable secondary school science and mathematics program. All science teachers should have a broad background in the sciences and mathematics, as well as specialization within the field of science. Breadth of background is necessary for three main reasons. First, as succeeding sections of this document will demonstrate, specialists in each field of science stress the need for study of related sciences for adequate understanding of the particular field. Second, since most high school science teachers, over a period of time, are assigned to teach several sciences, it is necessary to provide preparation in a variety of areas. Third, the teacher needs preparation in a variety of sciences so that he may in his teaching present a program that stresses for his students the interrelationships within and among the various fields and the significance of science as a human activity.

Professional Preparation

The preparation of a science teacher should include experience in planning and conducting laboratory experiments, in supervising the projects of individual students, and in devising laboratory equipment

when improvisation is necessary. In some colleges this may be achieved in science courses; in others it may be achieved in courses in the teaching of science and in student teaching. It is important that student teaching be carried on where supervising teachers have modern laboratory equipment and experience in its effective use.

Science and Mathematics Curriculum Studies

The teacher of the science and mathematics methods courses in the preparation institution should be a master teacher, well-qualified in subject-matter, a specialist in high school curricula and methods in his field and one who has the confidence and respect of both the subject area and education departments. The subject-matter department should participate in the methods courses, the supervision of student teaching, and the decision to recommend the student for certification as a high school teacher.

Common Guidelines

It is not necessary that all colleges adopt a uniform pattern of organization for providing the subject-matter preparation for the science teacher. Some institutions with a divisional organization may offer a curriculum for the preparation of science teachers through a single division. Others, with a departmental pattern of organization, may offer individual teaching majors through separate science departments, such as physics, chemistry, biology, etc. Whatever the type of organization, the subject-matter portion of the teacher's preparation should constitute a pattern carefully planned in accordance with these Guidelines.

The Guidelines for teacher preparation which follow, with some variation in wording, are held to be common to all the subject fields in science and mathematics.

GUIDELINE I: *The program should include a thorough, college-level study of the aspects of the subject that are included in the high school curriculum.*

GUIDELINE II: *The program should take into account the sequential nature of the subject to be taught, and in particular should provide the prospective teacher with an understanding of the aspects of the subject which his students will meet in subsequent courses.*

GUIDELINE III: *The program should include a major in the subject to be taught, with courses chosen for their relevance to the high school curriculum.*

GUIDELINE IV: *The major should include sufficient preparation for the later pursuit of graduate work in one of the sciences or in mathematics.*

GUIDELINE V:	***A fifth-year program should emphasize courses in the subject to be taught.***
GUIDELINE VI:	***The program should include work in areas related to the subject to be taught.***
GUIDELINE VII:	***The program should include preparation in the methods especially appropriate to the subject to be taught.***
GUIDELINE VIII:	***The program should take into account the recommendations for curriculum improvement currently being made by various national groups.***

A. Biology*

GUIDELINE I: *The program should include a thorough college-level study of the aspects of the subject that are included in the high school curriculum.*

In the major subject area of biology essential concepts to be included are:

A. The characteristics of living organisms in terms of maintenance (metabolism, including nutrition, transport and circulation, respiration, synthesis and excretion), regulation (hormonal control, neurophysiology, etc.), behavior (of the organism as a whole as well as its neural basis), reproduction, genetics, development (including growth and changing form and function), evolution (including some introduction to populations as evolutionary units), and, systematics (with emphasis on problems of classification);

B. The interrelationships of living organisms with their physical and biotic environments (ecology);

C. Significant emphasis on the plant, animal, and microbiological sciences alike (including the study of man as an animal);

D. Strong emphasis on the actual living materials through laboratory and field experiences; and,

E. Emphasis on science (and biology as a science) as investigation and inquiry, especially through experimental methods.

The understanding in areas mentioned in A. above shall be with reference to both plants and animals, and wherever relevant, to microorganisms as well. If suitable facilities for field work are not available they should be developed

GUIDELINE II: *The program should take into account the sequential nature of certain areas, and in particular should provide the prospective teacher with an understanding of the aspects of the subject which his students will meet in subsequent courses.*

A broad course in the principles of general biology, or the equivalent drawn from separate courses in botany, zoology, and microbiology, may include all of the topics mentioned above. Since this introduction cannot

*NOTE: It is requested that the Guidelines for Biology be used only with reference to the *Introduction* of this document.

provide adequate coverage, it will be necessary for the teacher to take advanced courses for suitable preparation.

Advanced courses in biology should be so selected as to maintain a broad knowledge of plants and animals alike, and may include plant physiology and structure, animal physiology and structure, ecology, plant and animal development, genetics, evolution, protozoology, phycology, and microtechniques. With few exceptions, all of these courses should include laboratory work of an experimental kind as well as descriptive studies. Preparation in the methods of biology teaching may be added.

GUIDELINE III: *The program should include preparation in the subject to be taught, with courses chosen for their relevance to the high school curriculum.*

In addition to introductory general biology, which should stress general principles and concepts applicable to plants, animals, and microorganisms, and which should include laboratory work, advanced courses should be elected to make a total of introductory and advanced courses approximately a full year of college work.

The advanced courses should be so selected as to avoid specialization in a particular area of biology or in a particular group of organisms. They should include a balanced study of significant biological phenomena as they appear in microorganisms, plants, and animals, and should be chosen to give teachers a deeper knowledge of as many as possible of the following broad areas: molecular and cellular biology; metabolic and regulatory biology; genetic biology; developmental biology; environmental biology; and systematic and evolutionary biology. It is recognized that colleges and universities can provide such a program through very different combinations of courses. The essential point is study of basic processes as they appear in examples drawn from all three major organismal groups (microorganisms, plants, animals). The high school biology curriculum requires this kind of broad understanding.

GUIDELINE IV: *The program should include sufficient preparation for the later pursuit of graduate work in biology.*

Any courses which are neither directly relevant to the high school program nor prepare for graduate study should be discouraged. For example, a course in the systematics of a very limited group of organisms offers but little to the first objective named, and is preparatory for graduate study only if the student definitely intends to specialize in work on that group.

GUIDELINE V: *A fifth-year program should emphasize courses in the subject to be taught.*

It is recommended that not less than half of the advanced study beyond the baccalaureate program be devoted to biology courses. A

biology teacher might choose to proceed toward a master's degree in biology which would make him especially well-suited to teach advanced placement courses in biology. Broadening courses in the history and philosophy of science, the development of experiments and demonstration techniques, and research participation would be valuable components of this program.

Advanced and continued study should not necessarily be considered to end with formal degree programs. Membership and participation in both professional scientific and professional education organizations can provide a continuous refreshment of knowledge and enthusiasm for science and teaching.

GUIDELINE VI: *The program should include preparation in areas related to the subject to be taught.*

The requirements for a teacher of biology appear to be more difficult to outline than for the teachers of other sciences and mathematics. Biology makes extensive use of understandings and techniques that are basically those of one of the other sciences, and this is growing in measure with every year. This means that to reach the desirable level of biological understanding, a prospective biology teacher needs a relatively large amount of work in related sciences.

Much of the necessary knowledge of related sciences can be developed through careful choice of elective courses that satisfy general education requirements. An understanding of the basic facts and principles which govern the relationships of matter and energy is imperative if the recent insights into life processes are to be introduced into the secondary school curriculum. A year of college physics together with a year of college chemistry may suffice to provide such a background; but it should be emphasized that in the field of chemistry an introduction to organic chemistry and biochemistry is needed. Where this is not provided in the introductory college course, additional work in chemistry is necessary. Some grasp of historical geology is necessary for a sound and effective interpretation of evolutionary theory. In some cases a sufficient background of this nature may be supplied in a biology course in evolution; but it is more frequently available as a semester or term course in geology. Some mathematics is required for an understanding of modern genetics, ecology, and physiology. This may include introductory calculus and a good foundation in probability and statistics. Psychology is important to the understanding of behavior. It must again be emphasized that the current structure of numerous aspects of the biological sciences is rapidly shifting, so that not only must explicit attention be given to areas of the related sciences now important to biology, but also to the need for frequent reappraisal of the relative importance of various scientific subjects to secondary school biology.

All in all, about one-fourth of the total four-year college program of a prospective secondary school biology teacher should be allotted to the

related science fields and mathematics, approximately equal to the amount of work taken in biology itself.

GUIDELINE VII: *The program should include preparation in the methods especially appropriate to the subject to be taught.*

Most courses in biology taken by prospective secondary school biology teachers should include laboratory or field work. Particular attention in all biology courses to the design of experiments and the development of demonstration equipment can be a valuable adjunct. It is strongly recommended that a special course be planned that will provide the prospective biology teacher with the special skills and techniques that are necessary to conduct an effective laboratory program.

As the Biological Sciences Curriculum Study says: "... One thing (is) of prime significance. The laboratory is where the work of science is done, where its spirit lives within those who work there, where its methods are transmitted from one generation to the next. One does not really learn science from books, one learns science by asking nature the right questions. And the laboratory (or field) is the place where one learns most readily what questions can be asked fruitfully, and how they must be put. It is where one learns why science insists on precise measurements, accurate observations, and conciseness and clarity in communication."

Laboratory and field work appropriate to learning the methods and subject matter of a college course is not always appropriate or adequate in the education program for a secondary school biology teacher, who must plan and develop methods suited to the high school yet conveying the nature and methods of modern scientific investigation. It is strongly recommended that wherever existing courses are not planned with this need in mind, special training in laboratory demonstration and technique, planning of experiments, and field work be included.

GUIDELINE VIII: *The program should take into account the recommendations for curriculum improvement currently being made by various national groups.*

Since the teacher may well be asked to teach courses such as those being designed by the Biological Sciences Curriculum Study, the teacher should be prepared to teach these as well as more traditional courses. It may be noted that the modern courses offer considerable flexibility and choice on the part of the teacher, so that absolute uniformity in teacher preparation is not sought and is not to be considered desirable.

B. Chemistry*

GUIDELINE I: ***The program should include a thorough, college-level study of the aspects of the subject that are included in the high school curriculum.***

This is intended to mean a systematic study of chemistry in which fundamental principles are inter-related and illustrated with suitable descriptive and historical material. While the specific treatment, emphasis, arrangement, order, and detail of course content should be left to the respective faculties of individual institutions, the over-all preparation of the high school chemistry teacher should include work in the following areas:

A. *General Inorganic Chemistry:* Composition and structure of matter, atomic and molecular theory, states and transitions of matter, stoichiometry, nature of solutions, periodic tables and relationships among the elements, rates and equilibrium, ionic equilibrium and properties of electrolytes, oxidation-reduction and electro-chemistry, energy relationships, nuclear and radiochemistry, and a study of the inorganic chemistry of important elements.

B. *Organic Chemistry:* Important types of organic reactions interpreted in terms of bonding orbitals, kinetics, thermo-dynamics and spatial relationships; application of these principles to some processes and compounds of particular interest because of their theoretical, industrial, or biochemical importance.

C. *Analytical Chemistry:* Gravimetric, volumetric, and instrumental methods, their applications and limitations.

D. *Physical Chemistry:* Determination of precise physical properties and the application of these data to thermodynamics, kinetics, and structure.

GUIDELINE II: ***The program should take into account the sequential nature of certain areas, and in particular should provide the prospective teacher with an understanding of the aspects of the subject which his students will meet in subsequent courses.***

*NOTE: It is requested that the Guidelines for Chemistry be used only with reference to the *Introduction* of this document.

GUIDELINE III: *The program should include a major in chemistry to be taught, with courses chosen for their relevance to the high school curriculum.*

GUIDELINE IV: *The program should include sufficient preparation for the later pursuit of graduate work in chemistry.*

Since both physical chemistry and certain courses in physics require a working knowledge of the calculus, the depth in mathematics should include treatment in this area.

GUIDELINE V: *A fifth-year program should emphasize courses in the subject to be taught.*

Typical possibilities for the fifth year are: work leading to a master's degree in chemistry; work leading to the degree of master of arts in teaching; and, advanced work of about 30 hours.

Each of these programs should be based on subject-matter courses in chemistry and the degree-granting institution should have considerable freedom in setting course requirements. In general, at least half of the advanced training beyond the baccalaureate program should be devoted to chemistry.

Advanced elective or fifth-year chemistry courses should be chosen from among courses in advanced inorganic chemistry, biochemistry, radiochemistry, qualitative organic analysis, and thermodynamics. Broadening courses in the history and philosophy of science, the development of experiments and demonstration techniques, and research participation would be valuable adjuncts to the fifth-year program.

GUIDELINE VI: *The program should include preparation related to the subject to be taught.*

Foundation training for teaching chemistry should include adequate basic study in physics, mathematics, and biology. Since a part of the physics study requires a working knowledge of calculus the requirement in mathematics should include this area.

GUIDELINE VII: *The program should include training in the methods especially appropriate to the discipline to be taught.*

Laboratory experiments should be an integral part of each chemistry course. Particular attention in all chemistry courses should be given to the design of experiments and the development and presentation of demonstrations which are valuable adjuncts to the student's science methods course.

GUIDELINE VIII: *The program should take into account the recommendations for curriculum improvement currently being made by various national groups.*

Since the teacher may well be asked to teach courses such as those designed by the Chemical Bond Approach Project and the Chemical Education Materials Study, the teacher should be prepared to function competently in such courses as well as in the traditional ones. Even though the teacher may not be teaching such courses in their entirety, he should know and be adapting their recommendations to his work and be developing new materials on his own.

C. Physics*

GUIDELINE I: ***The program should include a thorough, college-level study of the aspects of the subject that are included in the high school curriculum.***

The specialized education of the physics teacher should consist of an intensive treatment of the fundamental or basic topics of physics rather than a random selection of courses, many of which might be only incidental to the high school curriculum. This degree of concentration in physics may be such as to constitute a physics major in some institutions.

A suggested group of courses would include:

A. *A one-year basic course in college physics.* This should be a course which pursues in depth the important and basic principles of physics. The most important topics are Newton's laws of motion; conservation of mass, energy, and momentum; conservation of charge; waves and fields; molecular structure of matter; and structure of the atom. Problem solving and laboratory experience are important aspects of this course. The laboratory especially should be designed to be a vital and interesting part of the course. It would be necessary for this course to include some ideas of the calculus until a time that the calculus can be made a concurrent requirement.

B. *Intermediate courses.* The basic course above, together with calculus, should be prerequisite for the intermediate courses suggested. The curriculum of the prospective high school physics teacher should include the subject matter of the following areas to the extent of at least one course in each: physical mechanics, heat and thermodynamics, optics, electricity and magnetism, and electronics. Emphasis should be on a thorough quantitative treatment of a limited number of important topics in these areas of classical physics. There should be some advanced laboratory work associated with these courses. Some of this intermediate physics may be offered in substantial integrated courses which should not be "survey" courses.

C. *A course in atomic and nuclear physics.* Atomic and nuclear physics should be traced through study of the phenomena, concepts, and experiments that are important to the understanding and appreciation of these newer areas of physics. Again, the number of topics considered

*NOTE: It is requested that the Guidelines for Physics be used only with reference to the *Introduction* of this document.

should be consistent with the goal of understanding emphasized in paragraphs A. and B. above. This course should utilize the mathematics background of the student and should have a well-developed laboratory program.

GUIDELINE II: *The program should take into account the sequential nature of the subject to be taught, and in particular should provide the prospective teacher with an understanding of the aspects of the subject which his students will meet in subsequent courses.*

GUIDELINE III: *The program should include a major in the subject to be taught, with courses chosen for their relevance to the high school curriculum.*

Adequate preparation for teaching physics at the high school level requires that the prospective teacher devote approximately one-fourth of his college program to courses in physics. The pattern of courses should provide for preparation in those topics which are a part of the high school curriculum in physics.

GUIDELINE IV: *The program should include sufficient preparation for the later pursuit of graduate work in physics.*

GUIDELINE V: *A fifth-year program should emphasize courses in the subject to be taught.*

It is recommended that no less than half of the advanced training beyond the baccalaureate program be devoted to science and mathematics courses. A physics teacher might choose to proceed toward a master's degree in physics which would make him especially well-suited to teach advanced placement courses in physics. He might, on the other hand, choose to build on his previous mathematics and science courses to obtain greater depth in these areas in preparation for future multiple science teaching assignments. Broadening courses in the history and philosophy of science, history and philosophy of education, the development of experiments and demonstration techniques, and research participation would be valuable adjuncts to the student's program.

Advanced and continued study should not necessarily be considered to end with formal degree programs. Membership and participation in both professional scientific and professional education organizations can provide a continuous refreshment of knowledge and enthusiasm for science and teaching.

GUIDELINE VI: *The program should include preparation in areas related to the subject to be taught.*

To acquire an adequate mastery of mathematics and breadth of understanding in the sciences, the prospective physics teacher will be re-

quired to devote approximately another fourth of his college program to courses in these areas:

A. A year course in the general principles of chemistry is almost mandatory for teaching physics. This course should include composition and structure of matter, atomic and molecular theory, states and transitions of matter, stoichiometry, nature of solutions, periodic tables and relationships, rates of reactions and equilibrium, ionic equilibrium and properties of electrolytes, oxidation-reduction and electrochemistry, energy relationships, and colloidal state.

B. The equivalent of four semester courses in mathematics including a year course in calculus is essential, and one semester of differential equations is desirable. If mathematics is to be a second teaching field additional mathematics courses would also be necessary.

C. A year course in principles of biology, including characteristics of living organisms, cell theory, structural system of plants and animals, metabolism, maintenance of individual (health and disease) is recommended.

D. A one-semester course selected from one of the following fields: geology, meteorology, physical geography, or astronomy is also recommended.

GUIDELINE VII: ***The program should include preparation in the methods and materials especially appropriate to the subject to be taught.***

GUIDELINE VIII: ***The program should take into account the recommendations for curriculum improvement, especially those made by national groups.***

Preparation in physics and mathematics of the kind described above will enable the experienced physics teacher to evaluate courses such as those prepared by the Physical Science Study Committee, to modify his own teaching in accord with this evaluation, and to contribute toward future curriculum studies in his own school and perhaps at the state or national level.

D. Physical Science*

GUIDELINE I: ***The program should include a thorough, college-level study of the aspects of those science areas which are included in the high school curriculum.***

The physical science teacher, as described here, is one who will teach primarily the physical science course in high school but who will be qualified also to teach either physics or chemistry or both.

The student preparing for this type of teaching assignment should devote as much of his undergraduate program to work in the basic sciences as was suggested for the prospective teachers of physics or chemistry. He should, however, distribute his undergraduate work in physics and chemistry about equally between the two.

Furthermore, a teacher of integrated courses in physical science will need to draw more of his teaching materials from other physical sciences, such as geology, astronomy, and meteorology, than will a teacher who teaches only physics or chemistry.

Since a major in chemistry or physics may be a five-year goal, it is important that the courses in the four-year program be acceptable in each major curriculum. A suggested group of courses following this Guideline would include:[1]

A. *A year course in the general principles of chemistry:* Composition and structure of matter, atomic and molecular theory, states and transitions of matter, stoichiometry, nature of solutions, periodic tables and relationships, reaction rates and equilibrium, ionic equilibrium and properties of electrolytes, oxidation-reduction and electrochemistry, energy relationships, and colloidal state.

B. *A semester or year course in organic chemistry:* Nomenclature, hydrocarbon series, functional groups and their basic reactions, typical methods of preparation, and application.

C. *A semester or year course in analytical chemistry:* Gravimetric, volumetric, and instrumental methods, their applications and limitations.

D. *A one-year introductory course in college physics:* This course should pursue in depth the important and basic principles of physics.

[1] Typical courses in chemistry or physics might meet for three hours a week for lecture and recitation, with an additional two- or three-hour period for laboratory work.

*NOTE: It is requested that the Guidelines for Physical Science be used only with reference to the *Introduction* of this document.

Some of the most important topics are Newton's laws of motion; conservation of mass, energy, and momentum; conservation of charge; waves and fields; molecular structure of matter; and structure of the atom. Problem solving and laboratory experience are important aspects of this course. The laboratory especially must give the student firsthand knowledge of the way in which a physicist approaches an experimental problem.

E. *Intermediate courses in physics:* Two one-semester courses chosen from the following subjects: thermodynamics, optics, electricity and magnetism, and electronics. Emphasis should be on a thorough quantitative treatment of a limited number of important topics in these areas of classical physics. There should be some advanced laboratory work associated with these courses. Institutions which are able to offer this material in one substantial integrated course should do so, but it must not be a survey course. It is essential that these courses be based on calculus as a prerequisite.

F. *A semester or year course in modern physics:* The development of atomic and nuclear physics should be traced through study of the phenomena, concepts, and experiments that are important to the understanding and appreciation of this new area of physics. Again, the number of topics considered should be consistent with the goal of developing an understanding of fundamental concepts. This course should utilize the mathematics background of the student and should have a well-developed laboratory program.

GUIDELINE II: *The program should take into account the sequential nature of the subject to be taught, and in particular should provide the prospective teacher with an understanding of the aspects of the sciences which his students will meet in subsequent courses.*

GUIDELINE III: *The program should include a concentration in one of the areas to be taught, with courses chosen for their relevance to the high school curriculum.*

GUIDELINE IV: *The concentration should include sufficient preparation for the later pursuit of graduate work in one of the physical sciences.*

By careful planning, the prospective physical science teacher may take enough undergraduate work in physics and chemistry so that he may be adequately prepared for graduate study in either field. In some cases, however, it may be necessary for the student to take work beyond that required for graduation.

GUIDELINE V: *A fifth-year program should emphasize courses in the subject to be taught.*

The fifth-year program should be devoted primarily to physics, chemistry, and mathematics, so as to strengthen the preparation for teaching the single subjects of chemistry and physics. Courses should be chosen from the more advanced courses described under the preparation of physics and chemistry teachers.

GUIDELINE VI: ***The program should include work in areas related to the subject to be taught.***

Approximately one-fourth of the program of teacher preparation for high school physical science should be devoted to courses in other natural sciences and mathematics, with emphasis on the related physical sciences of geology, astronomy, and meteorology.

A suggested group of courses would include:

A. Three of four one-semester courses distributed among the following fields: geology, meteorology, physical geography, and astronomy.

B. The equivalent of four semester courses in mathematics that should include a year course in calculus.

C. A year course in the principles of biology.

GUIDELINE VII: ***The program should include preparation in the methods especially appropriate to the subject to be taught.***

For a definition of processes and methods of instruction in science refer to the assumptions on the nature of scientific studies given in the introductory statement.

GUIDELINE VIII: ***The program should take into account the recommendations for curriculum improvement currently being made by various national groups.***

Since the teacher may well be asked to teach courses such as those designed by the Physical Science Study Committee, the Chemical Bond Approach Project, and the Chemical Education Materials Study, the teacher should be prepared to function competently in such courses as well as in traditional ones. In addition, there is a great deal of ferment in science at the junior high school level that will most certainly result in experimental approaches in the teaching of the physical sciences in these grades.

E. Junior High School Science*

GUIDELINE I: *The program should include a thorough, college-level study of those science areas included in the junior high school curriculum.*

Science in grades 7, 8, and 9 plays an unusually significant role in modern education. More youngsters study science in these grades than in all senior high school science courses combined. Furthermore, they encounter this science at a particularly impressionable age. It is possible that their interests in science can more easily be developed or destroyed in the years of junior high school than at any other similar time span. Therefore, in order to assure adequate science education at this level, the minimal science preparation for the teacher of science in the junior high school should encompass about forty (40) per cent of the studies in the undergraduate program.

These studies should be divided about equally among biology, chemistry, earth science, and physics, except that there should be a concentration in one of these areas. In addition, the total preparation should include the mathematics training needed for a functional understanding of these science areas.

GUIDELINE II: *The program should consider the sequential nature within, and the interrelationships among, the various science areas, and in particular should provide the prospective teacher with an understanding of the aspects of science that his students will meet in subsequent courses.*

Most of the objectives of science courses in grades 7, 8, and 9 are identical with the objectives of science instruction at other levels and in the specialized science subjects.

Among the objectives recognized as especially important in the junior high school years, and for which provision must be made, are these:

A. The transition from the generalized science program of the elementary school to the relatively specialized program of the senior high school;

B. The opportunity to penetrate areas of science more deeply than is possible in the elementary school; and,

*NOTE: It is requested that the Guidelines for Junior High School Science be used only with reference to the *Introduction* of this document.

C. The availability of information and guidance that will enable students to assess their abilities and interests and make intelligent decisions about future studies and occupations.

GUIDELINE III: *The program should include a concentration in science with courses chosen for their relevance to the junior high school curriculum.*

The extensiveness of the preparation of the science teacher in the junior high school should be comparable with that of the science teacher in the senior high school. However, the preparation of the former will emphasize breadth; that of the latter, depth.

Colleges and universities need to offer group, or broad field, majors in science for teachers of junior high school science. Such majors should enable the prospective teacher to complete the minimal science program proposed under Guideline I, and in addition, obtain some specialization in one of the sciences.

GUIDELINE IV: *The program should include sufficient preparation for the later pursuit of graduate work in science.*

The undergraduate science preparation of the junior high school science teacher should be sufficiently extensive so as to allow him to elect upper division and/or graduate courses that will be applicable toward an advanced degree in the sciences.

GUIDELINE V: *A fifth-year program for teachers should emphasize courses in science appropriate to those areas to which the teacher is assigned.*

A fifth-year program for the junior high school science teacher should include opportunities to complete a major in one science area if this was not accomplished in the undergraduate program, pursue graduate level work in this science area, and remove any deficiencies in the breadth of preparation that is needed for teaching science in the junior high school.

GUIDELINE VI: *The program should include preparation related to the sciences to be taught.*

The broad preparation in science recommended for the junior high school science teacher should stress the interrelationships among the sciences and include work in mathematics and in the history and philosophy of science.

GUIDELINE VII: *The program should include training in the methods especially appropriate to the science areas to be taught.*

The science teacher must be trained to adjust his content and method to the many types of organization and curricula that he will encounter in

various teaching situations. The science teacher in the junior high school needs to be well-grounded in the special problems of junior high school pupils and in junior high school instruction. He needs to be familiar with teaching aids and laboratory equipment appropriate to this level. He needs to be competent in guiding learning by means of field studies, demonstrations, laboratory experimentation, and research. He must understand the problems of individual differences in the junior high school and the methods of dealing with them. Well-organized methods courses in science will provide the skills and training that will enable the junior high school science teacher to function effectively in these areas.

GUIDELINE VIII: The program should take into account the recommendations for curriculum improvement currently being made by various national groups.

Since he may well be asked to teach courses such as those designed by current curriculum projects, the teacher should be prepared to function competently in such courses as well as in the traditional ones. Even though the teacher may not be teaching such courses in their entirety, he should know and be adapting their recommendations to his work and be developing new materials on his own.

An outcome of the present state of flux in 7th, 8th, and 9th grade science is the wide variety of approaches to the science programs. These programs are being influenced by widespread changes in elementary school science and affected by the current developments in courses of study for senior high school science. Some junior high school programs include two or three years of what is ordinarily termed "general science." Other programs are designed around one-year courses that emphasize "earth-space science," "life science," and "physical science."

Within the next few years efforts of scientists and teachers to develop new course materials for junior high school science are likely to be greatly accelerated. Programs for preparing teachers of junior high school science should, therefore, (1) familiarize teachers with efforts such as those of the Resources Materials Development Program (RMDP), Physical Sciences Study Committee (PSSC), Chemical Bond Approach Project (CBAP), Biological Sciences Curriculum Study (BSCS), Chemical Education Materials Study (CHEM), School Mathematics Study Group (SMSG), and Elementary School Science Project (ESSP); (2) enable teachers to discriminate from among the many efforts those that have meritorious implications for junior high school science programs; (3) have sufficient flexibility so that the meritorious implications can be encompassed within the programs; and (4) foster extensive student participation in science, rather than emphasizing the use of lectures, films, and demonstrations.

F. Mathematics*

GUIDELINE I: *The program should include a thorough, college-level study of the aspects of the subject that are included in the high school curriculum.*

Much of secondary school mathematics is devoted to algebra and geometry. Hence at least six semester hours should be devoted to each of these two subjects. These should be preceded by the analytic geometry and calculus sequence described under Guideline II.

A course in modern algebra is essential. It should begin with the study of the structure of the number system and include treatments of algebraic systems, such as groups, rings, and fields. Linear algebra, vectors and finite matrices should be included with some emphasis upon their geometric interpretation. As the content of this course is revealed to the prospective teacher, it is important to show him how it ties in with the high school program. He should be made aware of the structure of algebra and how from this structure one derives the manipulative techniques of algebra.

For geometry, further work is needed to develop courses suitable for teacher education. There is general agreement that the preparation of secondary school teachers should include a critical study of the development of Euclidean geometry from various postulational systems. It is expected that this might comprise one-fourth of the geometry sequence, and that most of the remainder of this sequence will be devoted to one or more of the following topics:

A. The development of Euclidean geometry from synthetic projective geometry, or the generalization of Euclidean geometry to projective geometry.

B. Euclidean and analytic projective geometries, to be given after the modern algebra course.

C. Euclidean and affine geometries.

D. Geometries other than Euclidean, such as geometry on the sphere, the non-Euclidean geometries, and finite geometries.

NOTE: These courses in algebra and geometry, together with those discussed below under Guideline II, form the bulk of the preparation recommended by CUPM for Level II teachers, i.e., teachers of the elements of algebra and geometry in grades 7-10.

*NOTE: It is requested that the Guidelines for Mathematics be used only with reference to the *Introduction* to this document.

GUIDELINE II: *The program should take into account the sequential nature of the subject to be taught, and in particular should provide the prospective teacher with an understanding of the aspects of the subject which his students will meet in subsequent courses.*

The recognition of the sequential nature of mathematics should include the successive extensions of number concepts: positive integers, integers, rational numbers, real numbers, complex numbers, and linear vector spaces.

Since analytic geometry and calculus are the next area of mathematics studied by many high school graduates, every prospective secondary school mathematics teacher should study analytic geometry and calculus.

The analytic geometry should include the material essential to the calculus and could be taken before or concurrently with the calculus as the mathematics department desires. Intuitive ideas and basic concepts must be stressed in the calculus as well as manipulative skills. Applications to natural and social sciences should be included. Approximately nine semester hours will be needed for analytic geometry and calculus.

GUIDELINE III: *The program should include a major in the subject to be taught, with courses chosen for their relevance to the high school curriculum.*

In addition to the algebra, geometry, and calculus courses recommended above, the courses to complete a major or teaching major in the college recommending the student for certification may be chosen from the offerings of the mathematics department and should include topics from probability, statistics, set theory, and elementary logic. Additional courses in algebra, geometry, number theory, probability and statistics, and analysis should be selected in accord with Guideline IV.

GUIDELINE IV: *The program should include sufficient preparation for the later pursuit of graduate work in mathematics.*

The content of the major in mathematics recommended in Guideline III should include sufficient preparation for the later pursuit of graduate work in mathematics relevant to the teaching of mathematics in advanced standing programs; e.g., introductory courses in calculus, linear algebra, probability and statistics. The work comprising the major should not include courses such as solid geometry, advanced Euclidean geometry, theory of equations, and mathematics of finance, although topics from these may find their places in other courses.

It is important that universities have graduate programs available which can be entered by teachers with a major in mathematics, recognizing that these students substitute greater breadth for lack of depth in

analysis as compared with an ordinary B.A. or B.S. with a major in mathematics. In other respects, graduate schools should maintain great freedom in designing graduate programs for teachers.

GUIDELINE V: *A fifth-year program should emphasize courses in the subject to be taught.*

Three possibilities for the fifth year are: work leading to a master's degree in mathematics; work leading to the degree of master of arts in teaching; and, thirty semester hours of advanced work.

All three of these programs should normally require that at least two-thirds of the work be in mathematics and the degree-granting institution should have considerable freedom in setting the course requirements. However, for any one of the three, there should be the mathematical content necessary to prepare the teacher to handle adequately the advanced placement courses in calculus in the high school. Also, for each of the three, there should be included one course showing the nature and breadth of the applications of mathematics.

One could look upon the fifth year as a time to fill in the gaps. This is particularly important for senior high school teachers. The first consideration should be given to topics from probability and statistics and set theory and mathematical logic, if these have not been studied at the undergraduate level. Then choices may be made from such courses as: topology, theory of numbers, advanced calculus, differential equations, numerical analysis, probability and statistics, projective geometry, foundations of real and complex analysis (including a rigorous definition of real numbers, limits, continuity, etc.).

GUIDELINE VI: *The program should include work in areas related to the subject to be taught.*

The undergraduate requirement should include a course in physics and a course in another field in which mathematics is applied. When possible, the work in mathematics should be further supported by study in philosophy, logic, chemistry, astronomy, physics, biology, psychology, or economics. In each case, this study should be pursued to the extent that the student will have encountered substantial applications of mathematics.

GUIDELINE VII: *The program should include preparation in the methods especially appropriate to the subject to be taught.*

The preceding Guidelines have dealt in detail with the subject-matter training of mathematics teachers. There are many other facets to the education of the scholarly, vigorous, and enthusiastic persons to whom we wish to entrust the education of our youth. Effective mathematics teachers must be familiar with such items as:

A. The objectives and content of the many proposals for change in our curriculum and texts.

B. The techniques, relative merits, and roles of such teaching procedures as the inductive and deductive approaches to new ideas.

C. The literature of mathematics and its teaching.

D. The underlying ideas of elementary mathematics and the manner in which they may provide a rational basis for teaching.

E. The chief applications which have given rise to various mathematical subjects. These applications will depend upon the level of mathematics to be taught, and are an essential part of the equipment of all mathematics teachers.

Such topics are properly taught in so-called "methods" courses. We would like to stress that adequate teaching of such courses can be done only by persons who are well-informed both as to the basic mathematical concepts and as to the nature of American public schools—and as to the concepts, problems, and literature of mathematics education. In particular, we do not feel that this can be done effectively in the context of "general" methods courses, or by persons who have not had at least the level of preparation described in Guideline V. The teacher of the mathematics methods course should be a master teacher, who has the confidence and respect of both the mathematics and education departments. The mathematics department should participate in the methods courses, the supervision of student teaching, and the decision to recommend the student for certification as a high school teacher.

GUIDELINE VIII: The program should take into account the recommendations for curriculum improvement currently being made by various national groups.

The program of preparation for secondary school mathematics teachers should take into account the recommendations for curriculum improvement now being made by such groups as the School Mathematics Study Group, the University of Illinois Committee on School Mathematics, and the University of Maryland Mathematics Project (Junior High School). The program should acquaint prospective mathematics teachers with the existence of new materials and continue to follow evolving curricula.

APPENDIX

Earth and Space Science*

GUIDELINE I: *The program should include a thorough college-level study of the aspects of the subject that are included in the high school curriculum.*

Earth and space science as taught in most schools includes the study of the solid earth, the atmosphere, the hydrosphere, and their relationship to the universe. An earth and space science teacher should, therefore, be well prepared in mathematics and basic sciences (biology, chemistry, and physics) and should have a major or minor in one of the earth sciences (astronomy, geology, meteorology, and/or oceanography) with supporting work in the other three.

GUIDELINE II: *The program should take into account the sequential nature of the subject to be taught, and in particular, should provide the prospective teacher with an understanding of the aspects of the subject that his students will meet in subsequent courses.*

Emphasis should be placed on the physical and biological aspects of the atmosphere, lithosphere, and hydrosphere and their interrelationship early in the preparation of an earth science teacher. In subsequent years, as his studies become somewhat more restricted to one of these areas, he will then continue to think within the framework of this interrelationship. Regardless of the grade level at which earth and space science is taught, the content affords excellent opportunities to discuss basic concepts of biology, chemistry, and physics that the student may have encountered earlier at a more general level or which he may encounter later at a more sophisticated level.

GUIDELINE III: *The program should include a major in the subject to be taught, with courses chosen for their relevance to the high school curriculum.*

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* This section is not included with the other subject-matter areas in the main document because it was not prepared until the end of the study. When using this section, however, please refer to *Introduction*.

It is recommended where possible that a major in the broad field of the earth sciences be taken. Where such programs are not available, a major in one of the included sciences (astronomy, geology, meteorology, and oceanography) should be taken with supporting work in each of the other three. The major in earth science should be supported by a minor in either mathematics, biology, chemistry, or physics and should include as a supplementary requirement: mathematics through calculus, at least one year of chemistry, at least one year of physics, and one year of biology.

GUIDELINE IV: *The major should include sufficient preparation for the later pursuit of graduate work in one of the earth sciences.*

An undergraduate degree in earth science, astronomy, geology, meteorology, or oceanography, should be supported by thorough preparation in the basic sciences to prepare prospective teachers to do graduate work in an earth science other than that in which they have taken their major at the undergraduate level. Broad undergraduate preparation in mathematics, biology, chemistry, or physics, supplemented with some work in earth science, would permit graduate work in any of the earth sciences.

GUIDELINE V: *A fifth-year program should emphasize courses in the subject to be taught.*

It is recognized that in the preparation of earth science teachers a substantial amount of the undergraduate program will be taken up by foundation courses in the basic sciences and that only introductory courses in astronomy, geology, meteorology, and oceanography may be offered in most teacher education institutions. It is therefore essential that the prospective earth science teacher devote most of the fifth year to rounding out his background in the earth sciences. Additional supporting courses in the other sciences are also recommended for the fifth-year program.

GUIDELINE VI: *The program should include work in areas relating to the subject to be taught.*

In addition to the essential science foundation courses, programs at the fourth- and fifth-year levels should provide an opportunity to develop in some depth the basic science that supports the teacher's major area of interest—physics, for example, if he is primarily interested in meteorology courses. The history and philosophy of science should also be included to round out the preparation of the earth science teacher.

GUIDELINE VII: *The program should include preparation in the methods especially appropriate to the subject to be taught.*

Since many earth science courses are taught at the eighth- and ninth-grade level, it is important that teachers of these courses be familiar with the special problems of junior high school pupils and with methods used in junior high school instruction. The teacher should be acquainted with teaching aids and laboratory equipment appropriate to this level and should be prepared to guide learning by means of demonstration, laboratory experimentation, research, and field studies. High school earth science teachers should receive preparation in essentially the same areas but for the appropriate grade level. Preparation in these areas is the responsibility of subject-matter specialists as well as education specialists.

GUIDELINE VIII: *The program should take into account the recommendations for curriculum improvement currently being made by various national groups.*

As is the case in the other sciences, emphasis and interpretation of phenomena studies in the earth sciences are constantly changing. For these reasons and also because earth science is an interdisciplinary science it is important that prospective earth science teachers be informed of new developments in all of the sciences. Curriculum materials developed by a study group in physics or biology might be as useful and important to an earth science teacher as it would be to a physics or biology teacher.

DIRECTORY OF ORGANIZATIONS WITH RELATED INTERESTS

AAAS—American Association for the Advancement of Science
1515 Massachusetts Avenue, N. W., Washington 5, D. C.
Executive Officer—Dael Wolfle
Publication—*Science* (weekly)
Cooperative Committee on the Teaching of Science and Mathematics
Chairman—Thornton L. Page, Department of Astronomy
Wesleyan University, Middletown, Connecticut
Secretary—Bernard B. Watson, Research Analysis Corporation
6935 Arlington Road, Bethesda 14, Maryland
STIP—Science Teaching Improvement Program (AAAS-Carnegie)
Director—John R. Mayor
1515 Massachusetts Avenue, N. W., Washington 5, D. C.
Publication—*Science Education News* (quarterly)

AACTE—American Association of Colleges for Teacher Education
1201 - 16th Street, N. W., Washington 6, D. C.
Executive Secretary—Edward C. Pomeroy
Publications—*Bulletin*, 18 nos.
Yearbook

ACE—American Council on Education
1785 Massachusetts Avenue, N. W., Washington 6, D. C.
President—Logan Wilson
Secretary—Edmund J. Gleazer
Publications—*The Educational Record* (quarterly)
Higher Education and National Affairs (irregular)

ACS—American Chemical Society
1155 - 16th Street, N. W., Washington 6, D. C.
Executive Secretary—Alden H. Emery
Publications—*Chemical and Engineering News* (weekly)
The Journal of the American Chemical Society (semimonthly)
Division of Chemical Education
Secretary—William B. Cook
Montana State College, Bozeman, Montana
Publication—*Journal of Chemical Education* (monthly)

AGI—American Geological Institute (NAS-NRS)
2101 Constitution Avenue, N. W., Washington 25, D. C.
Executive Director—Robert C. Stephenson
Publication—*Geo Times*, 8 nos.
Committee on Teaching Resources Development (Duluth Conference) (NSF)
Chairman—Robert L. Heller, Department of Geology
University of Minnesota, Duluth, Minnesota
Publication—*Source Book of Geology and Related Sciences for Elementary and Secondary Science Teachers*

AIBS—American Institute of Biological Sciences
Suite 511, 2000 P Street, N. W., Washington 6, D. C.
Executive Director—Hiden T. Cox
Publications—*AIBS Bulletin* (bimonthly)
Quarterly Review of Biology
Proceedings of the Academy of the USSR (Doklady), Microbiology, Plant Physiology, Soviet Soil Science, and Entomological Review

AIP—American Institute of Physics
335 East 45th Street, New York 17, New York
Director—Elmer Hutchisson
Secretary—Wallace Waterfall
Publications—*Review of Modern Physics* (quarterly)
American Journal of Physics, 9 nos.

BSCS—Biological Science Curriculum Study (AIBS-NSF)
Director—Arnold P. Grobman
University of Colorado, Boulder, Colorado
Publication—*BSCS Newsletter*

CBAP—Chemical Bond Approach Project (NSF)
Director—Laurence E. Strong
Earlham College, Richmond, Indiana
Publications—*CBA Chemistry*
CBA Chemistry Laboratory
CBA Chemistry Laboratory Teachers' Guide

CHEM—Chemical Education Materials Study (NSF)
Project Director—J. Arthur Campbell
Harvey Mudd College, Pomona, California
Publications—*Chemistry, an Experimental Science*

CCSSO—Council of Chief State School Officers
1201 - 16th Street, N. W., Washington 6, D. C.
Executive Secretary—Edgar Fuller

CCTE—Council on Cooperation in Teacher Education (ACE)
1785 Massachusetts Avenue, N. W., Washington 6, D. C.
Secretary-Treasurer—Howard R. Boozer
Publication—*CCTE Newsletter*

CUPM—Committee on the Undergraduate Program in Mathematics (MAA-NSF)
Executive Director—Robert J. Wisner
Michigan State University, Oakland
Rochester, Michigan

ESSP—Elementary School Science Project
Director—Robert Karplus, Professor of Physics
University of California, 2232 Piedmont Avenue,
Berkeley 4, California

HEW-USO(E)—Department of Health, Education, and Welfare—U. S. Office of Education
330 Independence Avenue, S. W., Washington 25, D. C.
Commissioner of Education—Sterling M. McMurrin
For publications write to: Superintendent of Documents
U. S. Government Printing Office
Washington 25, D. C.

MAA—Mathematical Association of America
Executive Director—Harry M. Gehman, Department of Mathematics
University of Buffalo, Buffalo 14, New York
Publication—*American Mathematical Monthly*, 10 nos.

NASDTEC—National Association of State Directors of Teacher Education and Certification
President—Genevieve Starcher, Director
Division of Teacher Preparation and Professional Standards
State Department of Education
Charleston 5, West Virginia

NASDTEC-AAAS Teacher Preparation-Certification Study (Carnegie)
1515 Massachusetts Avenue, N. W., Washington 5, D. C.
Director—John R. Mayor
Associate Director—William P. Viall
Publication—*Guidelines for Preparation Programs of Teachers of Secondary School Science and Mathematics*

NCA—National Commission on Accrediting
1785 Massachusetts Avenue, N. W., Washington 6, D. C.
Executive Secretary—William K. Selden
Publications—*Newsletter* (irregular)
Handbook

NCATE—National Council for Accreditation of Teacher Education
Mills Building, 17th Street and Pennsylvania Avenue, N. W.,
Washington 6, D. C.
Director—W. Earl Armstrong
Publication—*List of Institutions* (annually)

NCRAA—National Committee of Regional Accrediting Agencies of the U. S.
Secretary—C. Scott Porter
Johnson Chapel, Amherst College, Amherst, Massachusetts
Publication—*Accredited Institutions of Higher Education*

NCTEPS—National Commission on Teacher Education and Professional Standards (NEA)
1201 - 16th Street, N. W., Washington 6, D. C.
Executive Secretary—Don Davies
Publications—*Journal of Teacher Education* (quarterly)
Newsletter (quarterly)

NCTM—National Council of Teachers of Mathematics (NEA)
1201 - 16th Street, N. W., Washington 6, D. C.
Executive Secretary—M. H. Ahrendt
Publications—*Mathematics Teacher*, 8 nos.
Arithmetic Teacher, 8 nos.
Mathematics Student Journal, 4 nos.
Yearbook

NSF—National Science Foundation
1951 Constitution Avenue, N. W., Washington 25, D. C.
Director—Alan T. Waterman
For information, write to Course-Content Improvement Section

NSTA—National Science Teachers Association (NEA)
1201 - 16th Street, N. W., Washington 6, D. C.
Executive Secretary—Robert H. Carleton
Publications—*The Science Teacher*, 8 nos.
Elementary School Science Bulletin

PSSC—Physical Science Study Committee (NSF)
Project Director—Jerrold R. Zacharias, Department of Physics
Massachusetts Institute of Technology
Cambridge, Massachusetts
Publications—*Science Study Series*

RMDP—Resources Materials Development Program (See AGI)

SMSG—School Mathematics Study Group (NSF)
Director—E. G. Begle, School of Education
Stanford University, Stanford, California
Publications—*Mathematics for Junior High School* (Grades 7 and 8)
Mathematics for High School (Grades 9-12)
Newsletter
Studies in Mathematics
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To order publications write to: Drawer 2502A, Yale Station
New Haven, Connecticut

STEP—Sequential Tests of Educational Progress (ETS)
Director—John Dobbin, Cooperative Test Division
Educational Testing Service, Princeton, New Jersey
Publications—*STEP Tests*—Reading, Writing, Listening, Social Studies, Science, and Mathematics
Teacher's Guide

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Additional copies may be obtained from state directors of teacher education and certification or by writing to NASDTEC-AAAS Studies, 1515 Massachusetts Avenue, N. W., Washington 5, D. C.

NASDTEC DECLARATION OF POLICY

The changing needs of society make increasing demands on teachers for the education of all citizens. If the teacher is to meet these demands, his education must be broader and more intensified than ever before.

Every state requires a license for those who direct the education of children and youth in order to protect and promote the educational welfare of its citizens. Similar provisions exist for licensing in all professions. The state directors of teacher education and certification are the administrators of this legal authority for state licensing of teachers. The National Association of State Directors of Teacher Education and Certification, recognizing the obligation of states to provide competent teachers for their youth, will continue to work for the improvements needed in the education and certification of teachers.

NASDTEC believes that the growing and changing demands on society in the last half of the twentieth century require that:

1) Prospective teachers be carefully selected from among our more capable college students.

2) The beginning teacher have completed a well-planned college program of at least four years.

3) All teachers have a broad education in the arts, the sciences and the humanities; intensive study in the subject-matter field(s) to be taught; and thorough preparation in the educational process.

4) School districts assign teachers only to subject-matter field(s) in which they are adequately prepared.

5) Standards and procedure for approving colleges and universities which prepare teachers be strengthened and enforced.

6) Reciprocity in teacher certification among the states be accorded to graduates of approved teacher-education programs in colleges and universities.

NASDTEC believes that the quality of the educational program is directly affected by the quality of the teacher. Furthermore, the association believes that to attract and retain competent teachers, it is necessary that increased funds be provided to raise the economic status of teachers and to improve teaching conditions.

NASDTEC will continue to work for the objectives which its members consider vital to the needed improvement of our system of public education. The members in their respective states, as well as in their national association, will continue to work closely with lay and professional groups and persons to improve programs of teacher education throughout the United States.